CENTRAL ASIA NATURAL RESOURCES MANAGEMENT PROGRAM
TRANSBOUNDARY WATER AND ENERGY PROJECT

ELECTRICITY LOSS REDUCTION DEMONSTRATION MODELS

INITIAL PERFORMANCE MONITORING RESULTS FOR SEVERELECTRO AND OSHELECTRO PILOT AREAS

Central Asia Natural Resource Management Program
Contract No. LAG I-00-99-00019-00
Order No: 809

Funded by:

U.S. Agency for International Development
Regional Mission for Central Asia
Office of Energy and Water
Park Palace Building
41 Kazybek bi Street
Almaty, 480100
Republic of Kazakhstan
(7-3272) 50-76-17

Prepared by:

PA Consortium Group
144A Tchaikovsky Street
Almaty, 480091
Republic of Kazakhstan
(7-3272) 50-10-74

and

PA Government Services, Inc.
1750 Pennsylvania Avenue NW, #1000
Washington, DC 20006
(202) 442-2000

July 21, 2004

DISCLAIMER

This publication was made possible through financial support provided by the United States Agency for International Development (USAID) Regional Mission for Central Asia, Office of Energy and Environment Initiatives, under Contract Number: 284-C-00-00-00025-00. The views expressed herein are those of PA Government Services, Inc. and do not necessarily reflect the views of USAID.

TABLE OF CONTENTS

LIST OF ACRONYMS

KfW	Kreditanstalt fur Wiederaufbau Germany
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt hour
ELCU	Electricity Loss Control Unit
NRMP	Central Asia Natural Resources Management Program
SEA	State Energy Agency
SECO	Switzerland State Secretariat for Economic Affairs
TWEP	Transboundary Water and Energy Project
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

Background

The Kyrgyz Republic energy sector has serious problems. Winter electricity demand is now twice that of the pre-independence years, due to the growth in residential electric heating loads and reduction of industrial loads. Electricity demand on a typical winter day is now three times that of a typical summer day. The growth in residential electric heating has been stimulated by low tariffs and a lack of legal and regulatory discipline and non-compliance in the electric power sector, thus displacing coal and natural gas for heating, hot water, and cooking. This has led to a sharp rise in the loads on urban distribution systems and very high technical and non-technical electricity losses.

Tariffs are well below the cost of operations, making it impossible to finance sustainable maintenance and rehabilitation of existing power facilities, let alone invest in new facilities. Electricity losses are very high (36%, according to official 2003 statistics), so that revenues entitled by tariffs are well below actual recovery. The high Kyrgyz winter electricity demand is at the core of the current regional water and energy problems in the Syr Darya Basin, creating tensions with neighboring countries and continuing problems with the energy and water nexus.

One of the promising measures to rapidly mitigate this condition is to reduce the high level of technical and non-technical electricity losses in Kyrgyzstan. Considering the attempts of the Government of Kyrgyzstan (Government) to improve the situation, and its relevance to the regional energy and water nexus, the United States Agency for International Development (USAID) Central Asia Natural Resources Management Program, Transboundary Water and Energy Project, supports the implementation of three electricity loss reduction demonstration models in electric power generation, transmission, and distribution.

The distribution level demonstration model consists of an individual pilot area within each of the three joint stock companies (Severelectro, Oshelectro, and Vostokelectro) to address shortcomings in major areas of operations, particularly internal distribution metering, customer metering, and billing and collection of payments. This report presents data and information from performance monitoring within the pilot areas of Severelectro (located in Bishkek) and Oshelectro (located in Osh). Following the detailed design, the installation phase of these two pilot areas was completed in November 2003 when performance monitoring of the demonstration model in the pilot areas started.

Qualifications of the Scale and Scope of this Report

It should be recognized that data and information presented in this initial performance monitoring report are preliminary and need to be interpreted with caution because of the following reasons:

- The pilot areas are relatively small and may not be representative of electric power sector conditions throughout the country;
- The performance monitoring period considered in this report is relatively short (November 2003 through April 2004), as more data and information are needed to make more reliable projections and to better analyze trends;

- The main operational indicators used in this report to assess changes in the pilot areas are:
  - Metered electricity consumption per customer, using tamper-proof electronic meters;
  - Technical electricity losses (primarily due to infrastructure capabilities); and
  - Losses through unmetered electricity consumption.
- It should be noted that unmetered electricity consumption includes:
  - Theft through meter tampering or meter bypass by customers;
  - Broken meters that don't properly register electricity consumption;
  - Theft by illegal connection of non-registered consumers. Such theft occurs at the 0.4 kV network distribution level and the 10 kV network distribution level; and
  - Electricity billing and collection of payments from consumption that was not metered and is based on "norms" (i.e., estimated consumption, dependent upon size and number of inhabitants in a living space), since this is relevant to the pilot areas before the installation of the tamper-resistant electronic metering infrastructure.
- Non-technical losses include:
  - Unmetered electricity consumption;
  - Customers that are improperly billed or do not fully pay for actual amounts of electricity consumption; and
  - Customers that are properly billed for actual amounts of electricity consumption but are negligent on payments.
- Overall, technical and non-technical losses result in lower revenues to electric companies and increased cost of electricity supply to customers.

Goals and Objectives

The three electricity loss reduction demonstration models are intended to show that the following goals can be achieved:

- Electricity technical and non-technical losses can be accurately documented by upgrades in infrastructure, primarily metering and rehabilitation of substations; and
- Shortfalls in electricity revenues to the power sector (due to technical and non-technical electricity losses) can be directly calculated from upgrades in infrastructure.

The objectives of this initial report are to identify and analyze:

- Changes in the metered consumption of electricity in the Bishkek and Osh pilot areas;
- Trends in electricity distribution losses;
- A preliminary estimate of the recovery period of the investment in tamper-resistant electronic metering and substation upgrades;
- Shortcomings in the management practices of Severelectro and Oshelectro; and

- A general lack of legal and regulatory enforcement by the State Energy Agency (SEA) and non-compliance by electric power companies.

Pilot Areas and Installation of Meters

The pilot area in Bishkek covers 242 individual houses, four commercial enterprises, and two apartment buildings, each with 90 customers. The pilot area in Osh covers 142 individual houses, two apartment buildings, each with 120 customers.

In these pilot areas, new tamper-resistant electronic electricity meters were installed at three levels:

- 10 kV feeders that serve several 0.4 kV transformer substations;
- 0.4 kV transformer substations that serve customers; and
- Individual houses, apartments, and commercial enterprises.

The 10 kV feeders also serve transformer substations outside the pilot areas. Storage sheds and garages near the apartment buildings were not provided with new meters. Also the camps of transients settled in the Osh pilot area were not provided with new meters.

Illegal connections were removed in the two pilot areas and, where necessary, essential circuits were rewired in accordance with operational and safety standards. Performance monitoring of the demonstration model in the two pilot areas began in November 2003 after all new tamper-resistant electronic meter installations were completed.

Performance Monitoring

The following operational indicators are being used to compare changes in the pilot areas as a result of the installation of tamper-resistant electronic metering:

- Metered consumption of electricity per customer;
- Total level of technical losses and unmetered electricity consumption;
- Billing capability; and
- Collections of payments.

Performance monitoring indicators for billing capability and collections of payments from customers are planned, but have not been addressed in this report, due to the lag time in data and information gathering by the distribution companies.

Changes in Metered Consumption

Major increases in metered electricity consumption were recorded in both pilot areas in comparison with the baseline period before demonstration model implementation. Tamper-resistant electronic metered consumption of individual houses has increased by 257% in Bishkek and 179% in Osh. The increase in metered electricity consumption in the apartment buildings in both areas was less and ranged between 10% in Bishkek to 80% in Osh. The initial data and information collected as a result of these two pilot areas indicate that individual houses offer a greater potential for reduction of residential electricity losses. Apartment buildings should be monitored using master meters to establish the urgency to replace individual meters of individual customers.

Distribution Electricity Losses

Despite the major increase in metered electricity consumption, there remains a high level of electricity losses at the 0.4 kV and 10 kV network levels after the installation of the tamper-resistant electronic metering infrastructure.

At the 0.4 kV network level, the electricity losses were recorded at higher levels in both Bishkek and Osh during November through January (45.4% to 32.9%) and at lower levels from February through April (23.0% to 10.6%). During this monitoring period, it was observed that there was a general downward trend of electricity losses (greater than 100% in Bishkek and nearly 200% in Osh). These abnormally high electricity losses can only for a minor part be explained by technical losses. International experience indicates that the normal level of expected technical losses at the 0.4 kV network level range from 3% to 5%. Thus, excess electricity losses in the pilot areas are presumed to be unmetered electricity consumption, assuming that the infrastructure is comparable to international standards.

Further data and information need to be collected to justify any conclusions on electricity losses at the 0.4 kV network level. However, initial impressions are that incentives for unmetered electricity consumption are greater during colder winter months, since electricity is the primary form of heat for individual houses within the two pilot areas. It could also be that the two distribution companies are enforcing more aggressive disconnections of illegal connections during the later months of the performance monitoring period, based on better metering systems.

The electricity losses at the tamper-resistant electronic metering of the 10 kV network level in the Bishkek pilot area were 4.4% in December 2003, but increased up to threefold from January through April 2004 (11.4% to 14.2%). After low levels of electricity losses during the first three monitoring months in the Osh pilot area (0.8% to 2.0% from mid-November 2003 until mid-February 2004), they spiked upwards and reached levels of 10.24% in mid-March and 15.15% in mid-April. International experience indicates that the normal level of expected technical losses in non-extended 10kV feeders is within 2% to 3%. Thus, the excess electricity losses consist of unmetered electricity consumption from the 0.4 kV transformer substations connected to the non-extended 10kV feeders inside and outside of the pilot areas. However, it's also possible that some of the 0.4 kV transformer substations outside the pilot area have old defective meters, giving inaccurate readings. In any event, the data and information indicate that electricity losses dramatically increased in the last few months of the performance monitoring period.

As sufficient metering infrastructure is now in place in the pilot areas, the high levels of unmetered consumption at the 0.4 kV and 10 kV network levels can only be explained by lack of management or enforcement capability at both distribution companies. It is not unreasonable to expect that these electricity losses can be considerably lowered by sound management and constant monitoring of this segment of the distribution network.

Legal and Regulatory Enforcement

It is apparent that the SEA does not have the support (i.e., financing and political will) from the Government that is necessary to properly conduct its responsibilities and authorities in the regulation of the electric power sector. The problems of high technical and non-technical electricity losses are only an indicator of many other non-compliance issues by these natural monopolies.

Management Practices

The apparent high levels of unmetered electricity consumption after the installation of tamper-resistant electronic metering and the collection of reliable data and information, highlight the need for a serious review of management practices by the distribution companies. The continued persistence of illegal connections observed well after these were clearly identified indicates a disturbing lack of willingness or enforcement capability.

Management System

A proper system of checks and balances for both load measurements (master meter and individual meters) and the registration of all customers is essential to extract the benefit of any investment in new metering infrastructure**.**

Overall Performance of the Demonstration Model

Despite the persistent high level of electricity losses, significant improvement can be claimed by the implementation of the demonstration model in the two pilot areas, including:

- Due to upgrades in the distribution pilot areas, unmetered electricity consumption has been reduced, perhaps significantly in the reduction of technical losses and theft; and
- Investments in better metering can be economically and financially recovered within an acceptable timeframe.

Conclusions and Recommendations

It is a well-known fact by the donors and international financial institutions that the Laws "On Energy" and "On Electricity" have never been properly implemented since their adoption. It is recognized that the electric power natural monopoly companies are not being properly regulated by the SEA, due to the general lack of agency financing and "political will" by the Government. It is recommended that the Government strongly supports the SEA, so that it can properly conduct its duties and responsibilities, and correct the technical and non-technical electricity losses problem, which includes adoption and enforcement of:

- Strong penalties for theft of electricity;
- Customer metering, billing, and collection of payments system;
- Distinct and stringent disconnection and reconnection policies;
- A schedule for the gradual increase of tariff rates to eventually ensure the recovery of costs, and provide confidence for investment in system upgrades;
- A safety net program that subsidizes electricity payments for vulnerable low income customers; and
- Regulatory oversight of management, administration, and operational behavior of electric power natural monopolies (generation, transmission, and distribution).

Additionally, the following immediate measures to reduce distribution electricity losses are recommended:

- Install and implement a proper system of checks and balances for both load measurements (master meter and individual meters), and the registration of all customers;
- Give priority to tamper-resistant electronic metering improvements at individual houses. Apartment buildings should be monitored using master meters to establish the priority for replacement of the individual meters of each apartment;
- Reduce electricity losses at the 10 kV level by identifying first if all 0.4 kV transformer substations connected to the 10 kV feeder have any defective meters through proper balancing of power measurements, and then identify and remove illegal connections until that feeder's balance (input = output - technical losses) is reached;
- Make inspectors and their meter-readers directly responsible for explaining the difference between the master meter readings at each 0.4 kV transformer substation and the total metered consumption by customers in the area served by each transformer substation;
- Rotate meter-readers among service areas in order to prevent collusion between meter-readers and customers;
- Timely remove illegal connections to the 0.4 kV transformer substations and to the 0.4 kV network, including portable kiosks, storage sheds, garages, and camps of transients;
- Take legal action against persistent illegal connections in the pilot areas to illustrate that theft will not be tolerated by the distribution companies; and
- Apply disconnection procedures of non-paying customers, as described in the contract between the distribution company and the customer, and approved by the SEA.

In addition, it is recommended that the SEA and distribution companies follow up with a serious and sustained effort to control all forms of non-technical losses, including theft, inaccurate billing and incomplete collection through:

- The establishment of a small, but highly motivated Electricity Loss Control Unit (ELCU), inserted in the distribution company by the SEA, and directly answerable to this agency.
- Providing authority to the ELCU to look into every aspect of the operational chain between metering and collection. It would conduct three major types of activities: instruction, monitoring and enforcement.
- Drawing staff of the ELCU from different distribution companies to prevent the persistence of corruption. They would receive special incentive compensation based on results achieved.

The above conclusions and recommendations will be discussed with Severelectro, Oshelectro, the SEA, key Government officials, USAID and other donors, and international financial institutions that support reforms in the Kyrgyz energy sector, and plan to replicate the demonstration model in a larger scale.

To further reduce losses in both pilot areas, TWEP is considering providing further technical assistance and training on this issue to the management of Severelectro and Oshelectro. These companies and the SEA should also consider the implementation of country-wide public outreach activities targeted at the issues of tariff setting and cost recovery, metering, billing, collection of payments, and disconnection and reconnection policies.

1. INTRODUCTION

1.1. Background

The Kyrgyz Republic energy sector has serious problems. Winter electricity demand is now twice that of the pre-independence years due to the growth in residential electric heating loads and reduction of industrial loads. Electricity demand on a typical winter day is now three times that of a typical summer day. The growth in residential electric heating has been stimulated by low tariffs and a lack of legal and regulatory discipline and non-compliance in the electric power sector, thus displacing coal and natural gas for heating, hot water, and cooking. This has led to a sharp rise in the loads on urban distribution systems and very high technical and non-technical electricity losses.

Tariffs are well below the cost of operations, making it impossible to finance sustainable maintenance and rehabilitation of existing power facilities, let alone invest in new facilities. Electricity losses are very high (36%, according to official 2003 statistics), so that revenues entitled by tariffs are well below actual recovery. The high Kyrgyz electricity demand is at the core of the current regional water and energy problems in the Syr Darya Basin, creating tension with neighboring countries and continuing problems with the energy and water nexus. One of the promising measures to rapidly mitigate this condition is to reduce the high level of technical and non-technical electricity losses in Kyrgyzstan.

Considering the attempts of the Government of Kyrgyzstan (Government) to improve the situation, and the relevance of electricity loss reduction to the regional energy and water nexus, a task of the United States Agency for International Development (USAID) Central Asia Natural Resources Management Program, Transboundary Water and Energy Project (TWEP), was established to support electricity loss reduction in Kyrgyzstan. Under this task, electricity loss reduction demonstration models were implemented at the generation, transmission, and distribution levels. The demonstration model within the generation joint stock company, Power Plants, addresses unmetered deliveries from the Naryn Cascade of hydroelectric power facilities that provides 90% of the Kyrgyz electricity generation. At the transmission level, the demonstration model within the joint stock company National Grid addresses the lack of metering at the electricity delivery points between the transmission, generation, and distribution networks, and the absence of a proper data acquisition system. The distribution level demonstration model consists of a pilot area within each of the three joint stock companies (Severelectro, Oshelectro, and Vostokelectro) to address shortcomings in major areas of operations, particularly internal distribution metering, customer metering, and billing and collection of payments.

All of these demonstration models are being implemented in three phases: detailed design, installation, and performance monitoring. This report provides initial data and information from performance monitoring within the pilot areas of Severelectro (located in Bishkek) and Oshelectro (located in Osh). Following the detailed design, the installation phase of these two pilot areas was completed in November 2003. Background information on the design of these demonstration models is provided in the TWEP report "Support to Electricity Loss Reduction in the Kyrgyz Republic – Stage I: Identification of Demonstration Projects".

1.2. Qualifications of the Scale and Scope of this Report

It should be recognized that data and information presented in this initial performance monitoring report are preliminary and need to be interpreted with caution because of the following reasons:

- The pilot areas are relatively small and may not be representative of electric power sector conditions throughout the country;
- The monitoring period considered in this report is relatively short, as more data and information are needed to make more reliable projections and to better analyze trends;
- The main operational indicators used in this report to assess changes in the pilot areas are:
  - Metered electricity consumption per customer, using tamper-proof electronic meters;
  - Technical electricity losses (primarily due to infrastructure capabilities); and
  - Losses through unmetered electricity consumption.
- It should be noted that unmetered electricity consumption includes:
  - Theft through meter tampering or meter bypass by customers;
  - Broken meters that don't properly register electricity consumption;
  - Theft by illegal connection of non-registered consumers. Such theft occurs at the 0.4 kV network distribution level and the 10 kV network distribution level; and
  - Electricity billing and collection of payments from consumption that was not metered and is based on "norms" (i.e., estimated consumption, dependent upon size and number of inhabitants in a living space), since this is relevant to the pilot areas before the installation of the tamper-resistant electronic metering infrastructure.
- Non-technical losses include:
  - Unmetered electricity consumption;
  - Customers that are improperly billed or do not fully pay for actual amounts of electricity consumption; and
  - Customers that are properly billed for actual amounts of electricity consumption but are negligent on payments.
- Overall, technical and non-technical losses result in lower revenues to electric companies and increased cost of electricity supply to customers;
- An attempt was made to compare the metered electricity consumption during the short monitoring period with similar data for the same months in the previous year (before project implementation). Due to deficiencies in the metering infrastructure before project implementation (lack of meters and tampered meters, substation infrastructure deterioration, theft, etc.), findings and conclusions on changes in metered electricity consumption cannot be accurately determined. However, broad generalities can be observed and are approximated, based on reasonable assumptions;

- The comparison of unmetered electricity consumption before and after project implementation provides only an order of magnitude of the overall electricity loss reduction performance of the pilot areas, due to:
  - Deficiencies in the metering infrastructure before project implementation; and
  - The 10 non-extended kV feeders that supply bulk electricity to the pilot areas also provide electricity to large areas outside the pilot areas.

2. GOALS AND OBJECTIVES

The three electricity loss reduction demonstration models are intended to show that the following goals can be achieved:

- Electricity technical and non-technical losses can be accurately measured by upgrades in infrastructure, primarily metering and rehabilitation of substations; and
- Shortfalls in electricity revenues to the power sector (due to technical and non-technical electricity losses) can be directly calculated from upgrades in infrastructure.

The objectives of this initial report are to identify and analyze:

- Changes in the metered consumption of electricity in two selected pilot areas;
- Trends in electricity distribution losses;
- A preliminary estimate of the recovery period of the investment in tamper-resistant metering and substation upgrades;
- Shortcomings in the management practices of Severelectro and Oshelectro; and
- A general lack of legal and regulatory enforcement by the SEA and non-compliance by electric power companies.

It should be stressed that the Government can easily (and rapidly) change the deteriorating condition of the electric power sector by strongly supporting the State Energy Agency (SEA), both financially and through "political will". Under the laws "On Energy" and "On Electricity" the SEA is empowered to properly conduct its duties and responsibilities, which include adoption and enforcement of:

- Strong penalties for theft of electricity;
- Customer metering, billing, and collection of payments system;
- Distinct and stringent disconnection and reconnection policies;
- A schedule for the gradual increase of tariff rates to eventually ensure the recovery of costs and provide confidence for investment in system upgrades;
- A safety net program that subsidizes electricity payments for vulnerable low income customers; and
- Regulatory oversight of management, administration, and operational behavior of electric power natural monopolies (generation, transmission, and distribution).

It is apparent that electric power companies will continue to disregard legal and regulatory compliance without strong Government support of the SEA.

3. PROJECT IMPLEMENTATION

3.1. Issues Addressed

The Kyrgyzstan power system suffers from very high electricity losses. The losses amounted to more than 36% in 2003 according to official government reports. Based on this percentage of technical and non-technical losses, the lack of revenues to the electric power sector can be approximated at more than $50 US million in 2003. Lack of metering at the various network levels (generation, transmission, and distribution) makes it virtually impossible to determine how these losses are distributed within each segment of the network and between technical and non-technical losses.

In general, extrapolating from what was observed at the two pilot areas before project implementation, master meters on the non-extended 10 kV feeders are outdated and function poorly. Master meters at the 0.4 kV transformer substations are absent. However, distribution companies are mainly supported by metered service at the customer level, except for 10% to 15% of the customers who are billed on the basis of norms or estimated consumption. This situation prevents the tracking of power flows (internal power balancing) within the distribution network to detect inconsistencies and identify sources of losses. Moreover, customer metering is not adequate as old meters were generally installed inside the customer premises and are vulnerable to tampering and/or bypass. Finally, the existing metering, billing, and collections software used by the distribution companies does not support internal power balancing, even if all required metering infrastructure would be in place.

In addition to poor metering infrastructure, there is clearly an institutional problem resulting from the lack of regulation by the SEA. The current regulatory enforcement (or lack thereof) does not provide adequate incentives for sound management of distribution companies, which would include a meaningful strategy to reduce the high electricity losses and improve revenue collection.

3.2. Design and Installation of Metering Infrastructure

The two electricity loss reduction pilot areas were designed to address the shortcomings of distribution company operations in:

- Internal distribution metering and substations;
- Customer metering; and
- Billing and collections of payments.

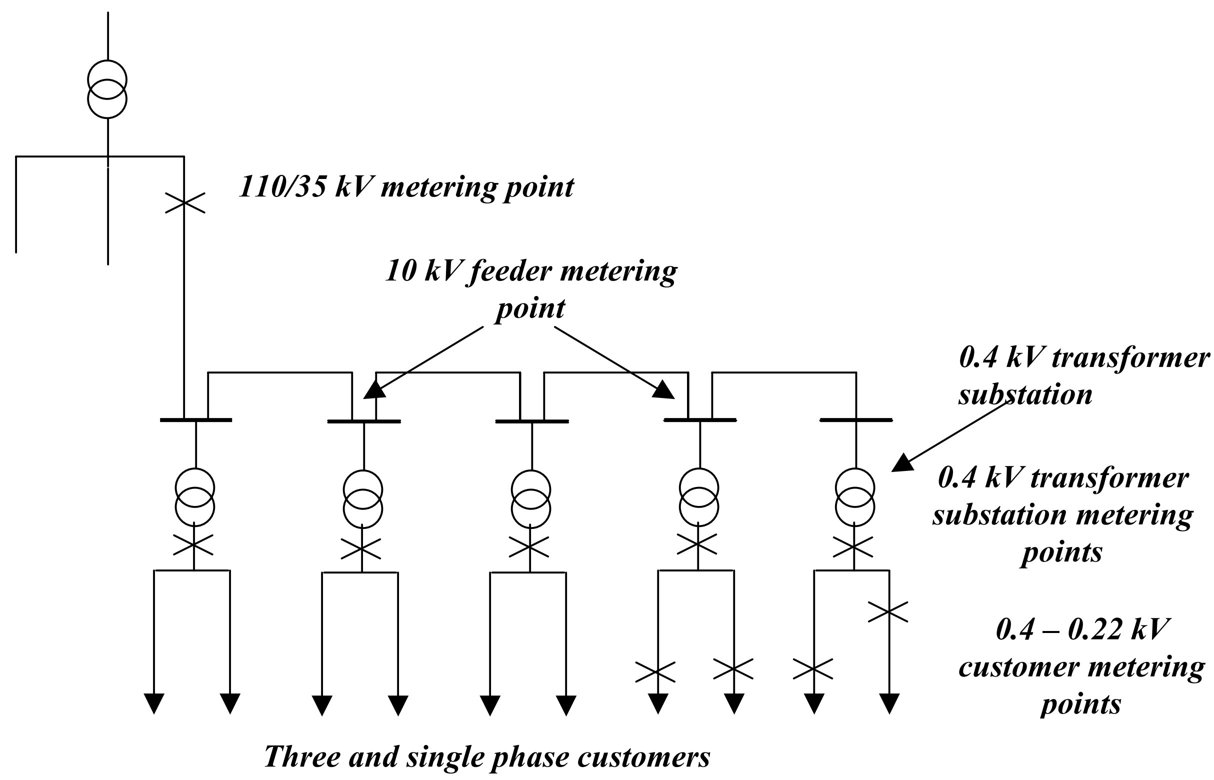
The Bishkek pilot area is located in Uchkun micro district. The selected non-extended 10 kV feeder serves 242 individual houses and four commercial enterprises through five transformer substations. The non-extended 10 kV feeder also supplies electricity to ten other transformer substations that serve residential and commercial enterprises outside of the pilot area. To balance measurements at the 10 kV and 0.4 kV network levels, master meters were installed at all 15 substations. Another non-extended 10 kV feeder serves two apartment buildings in the pilot area through one transformer substation. Each apartment building has 90 customers.

Storage sheds and garages located near the apartment buildings were not provided with meters.

The Osh pilot area is located in the northwest of the city. One of the selected non-extended 10 kV feeders (Jdanova) serves 142 individual houses through six transformer substations. The non-extended 10 kV feeder also supplies electricity to seven other transformer substations that serve residential and commercial enterprises outside of the pilot area. To balance measurements at the 10 kV and 0.4 kV network levels, master meters were installed at all 13 transformer substations. Another non-extended 10 kV feeder serves two apartment buildings in the pilot area through one substation in Tuleyken micro district. Each apartment building has 120 customers. It should be noted that many transients have settled in the pilot area and their camps were not provided with meters.

In the two pilot areas, a top-down metering approach was implemented, starting at the selected non-extended 10 kV feeders, through all the 0.4 kV transformer substations, to individual customers (Figure 1). Modern tamper-resistant electronic meters were chosen, procured, and installed at strategic locations to replace old obsolete meters, ensure against unmetered consumption, and gather accurate data and readings for customer consumption. Additionally, substations were rehabilitated, essential circuits were rewired in accordance with operation and safety standards, all unauthorized connections were removed, and previously unregistered customers were registered. A number of training sessions were provided to the distribution companies on the operation and maintenance of USAID supplied equipment.

FIGURE 1: SCHEMATIC LAYOUT OF THE METERING APPROACH



At the individual houses, new tamper-resistant electronic meters were installed in locked steel boxes outside of the house, but within the customer's premises for easy inspection and distribution company meter reader access. The boxes permit easy meter reading through a transparent panel. They are furnished with circuit breakers, which protect the meters from short circuits and simplify the disconnection of non-paying customers.

New tamper-resistant electronic meters were installed directly outside the front door of each apartment in one of the two apartment buildings in both pilot areas. In addition, a master meter was installed directly outside the fully metered apartment building. In the other apartment building for each pilot area, a master meter was installed outside the apartment building, but the individual meters of each apartment were not replaced. This approach will enable the distribution companies to compare the performance of master metering with and without complete re-metering of each individual apartment. If master metering of apartment buildings indicate low electricity losses, then the replacement of old individual meters at each apartment could have a lower priority since they are relatively accurate.

Performance monitoring of the demonstration model in the two pilot areas began in November 2003 after all new tamper-resistant electronic meter installations were completed.

3.3. Use of Installed Metering Infrastructure

The improved tamper-resistant electronic metering infrastructure in the two pilot areas provides the two distribution companies with three levels of accurate and reliable data and information on technical losses and unmetered electricity consumption, which include:

- Input to the non-extended 10 kV feeder that serves 0.4 kV transformer substations;
- Input to the 0.4 kV networks that serves customers; and
- Metering at customers (i.e., individual houses, apartments, and enterprises).

The improved metering configuration allows the distribution companies to balance the measurements of power flows at the 10 kV and 0.4 kV levels and between each 0.4 kV substation and its customers. The sum of inputs to all 0.4 kV transformer substations connected to a feeder should balance with the non-extended 10 kV feeder input minus technical losses and unmetered electricity consumption. The same balancing mechanism is implemented for each 0.4 kV transformer substation and the various customers served by the transformer substation.

These balance and control mechanisms allow the distribution companies to track power flows throughout the system. They better determine how electricity losses are distributed within the various segments of the network. These mechanisms also allow for the determination between technical losses or unmetered electricity consumption. Additionally, the new metering infrastructure would enable the companies to implement sound business practices, such as increased and accurate billing and disconnection policies.

4. INITIAL RESULTS OF PERFORMANCE MONITORING

4.1. Methodology

Comparative analysis is used to assess the initial performance of the two pilot areas, wherever justified. With the installation of tamper-resistant electronic meters, an attempt is made to compare metered consumption data during the monitoring period (November 2003 through April 2004) with similar data from old meters for the same months of the previous year. In addition, the readings of the various master meters that record bulk supply of electricity at the 10 kV and 0.4 kV network levels were used to estimate the electricity losses during the monitoring period.

All of the data and information were provided by the two distribution companies and is detailed in Annexes 1, 2, and 3 of this report. In Bishkek the meters are being read at the end of each month and the readings represent the electricity consumption during a full calendar month. In Osh the meters are being read in the middle of each calendar month. The readings represent electricity consumption during the last half and the first half of two consecutive calendar months.

The following operational indicators can be used to compare changes in the pilot areas as a result of the installation of tamper-resistant electronic metering:

- Metered consumption of electricity per customer;
- Total level of technical losses and unmetered electricity consumption;
- Billing capability; and
- Collections of payments.

Performance monitoring indicators for billing capability and collections of payments from customers are planned, but have not been addressed in this report, due to the lag time in data and information gathering by the distribution companies.

4.2. Customer Level Changes in Metered Consumption

Below is a comparative analysis of electricity consumption data and information from newly installed tamper-resistant electronic meters during the performance monitoring period and electricity consumption data and information from old meters during the same months a year earlier. Because of deficiencies in metering infrastructure before project implementation, the changes in metered electricity consumption data and information as a result of the demonstration model are not accurate, but can reasonably be presumed to be approximate.

4.2.1. Individual Houses

The changes in total metered consumption by individual houses in the two pilot areas are presented in Annex 1 and summarized in Figures 2 and 3. The data indicates a large increase in metered consumption after project implementation. The largest increases occurred during the coldest winter months. Per customer, the average monthly-metered electricity consumption increased from 350-kilowatt hours (kWh) to 900 kWh (an increase of 257%) in Bishkek and from 260 kWh to 465 kWh (an increase in 179%) in Osh.

FIGURE 2: BISHKEK PILOT AREA: TOTAL METERED CONSUMPTION OF INDIVIDUAL HOUSES (2003 – 2004)

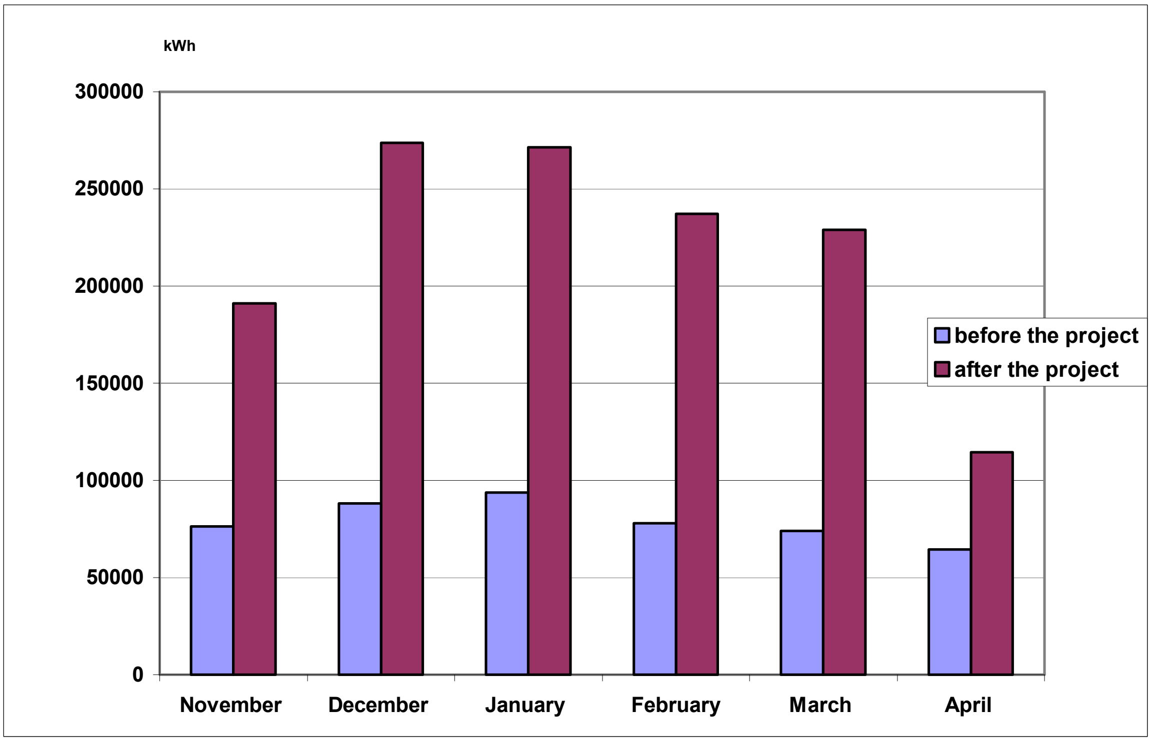
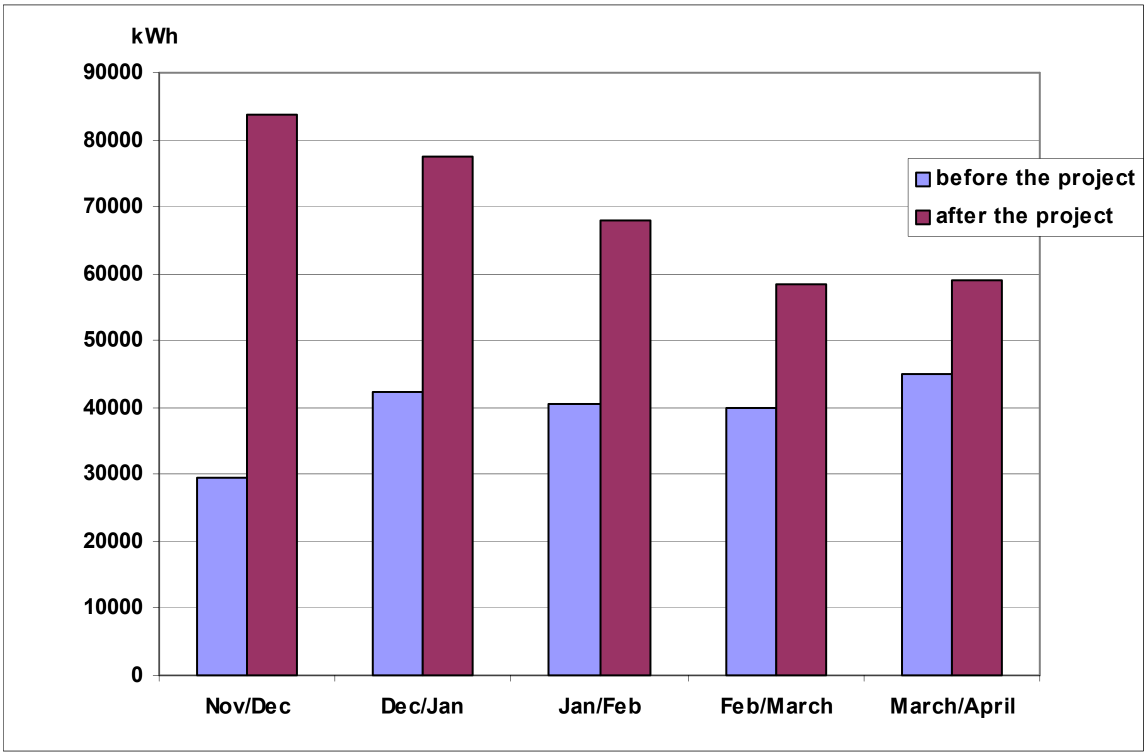


FIGURE 3: OSH PILOT AREA: TOTAL METERED CONSUMPTION OF INDIVIDUAL HOUSES (2003 – 2004)



It is noteworthy that the individual houses in both pilot areas are not served by either district heating or natural gas. Additionally, individual houses are not equipped with fuel oil or coal-fired furnaces. Therefore, any observed change in metered electricity consumption is not affected by changes in the energy source for heating. Moreover, Figure 4 shows that lower temperatures cannot explain the increase in metered electricity consumption during the winter of 2003/2004 in comparison with the previous winter.

FIGURE 4: AVERAGE MONTHLY TEMPERATURES IN DEGREES CENTIGRADE

	Bishkek		Osh	
	2002/2003	2003/2004	2002/2003	2003/2004
November	7.0	4.4	8.0	6.1
December	-4.3	-0.5	-2.8	-0.6
January	0.8	-0.4	1.9	1.8
February	0.6	3.0	2.8	4.5
March	5.1	5.5	6.3	7.8
April	8.8	12.4	11.3	13.9

Initial analysis of the metered electricity consumption by individual house customers may indicate an important operational deficiency of the distribution companies. Many individual house customers use three-phase meters and consume more than 4,320 kWh/month (6 kW x 30 days x 24 hours), but they are not registered as a “customer with installed capacity above 6 kW”. This means that these customers aren’t billed a capacity charge in addition to the electricity consumed. Although the installed meters allow for recording of maximum demand, neither Severelectro nor Oshelectro have used this feature to justify a higher tariff schedule for these customers.

4.2.2. Apartment Buildings

The changes in total metered consumption by apartment buildings in the two pilot areas are presented in Annex 3 and summarized in Figures 5 and 6. Although these increases in metered electricity consumption are substantial, they are considerably less than the recorded increases in electricity consumption by individual houses, particularly in Bishkek.

A possible explanation for the smaller increases in metered electricity consumption in apartment buildings as compared with individual houses is that the apartment buildings are connected to the district heating system. Thus, the electricity demand by apartments in winter is much less than the demand by individual houses, reducing the incentives for unmetered consumption. Another reason might be that unmetered electricity consumption by customers in apartment buildings is more visible to neighbors, further reducing the incentives for theft.

Per customer, the average monthly-metered consumption increased from 178 kWh to 194 kWh (an increase of 10%) in Bishkek and from 172 kWh to 307 kWh (an increase of 80%) in Osh. Thus, the potential for electricity loss reduction in the apartment buildings in Osh is larger than in the apartment buildings in Bishkek, according to this data. Another possible reason for the smaller increase in metered electricity consumption in apartment buildings in Bishkek is that the district heating system in Osh is less reliable.

FIGURE 5: BISHKEK PILOT AREA: TOTAL METERED CONSUMPTION IN APARTMENT BUILDINGS (2003 – 2004)

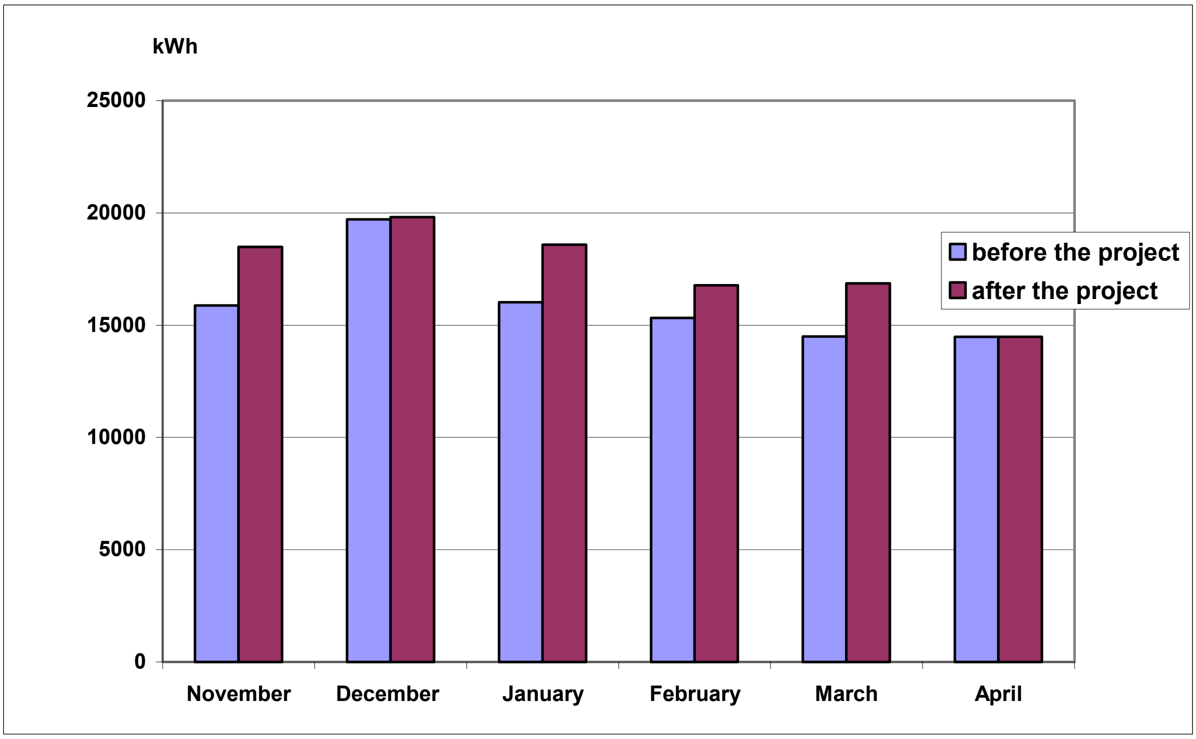
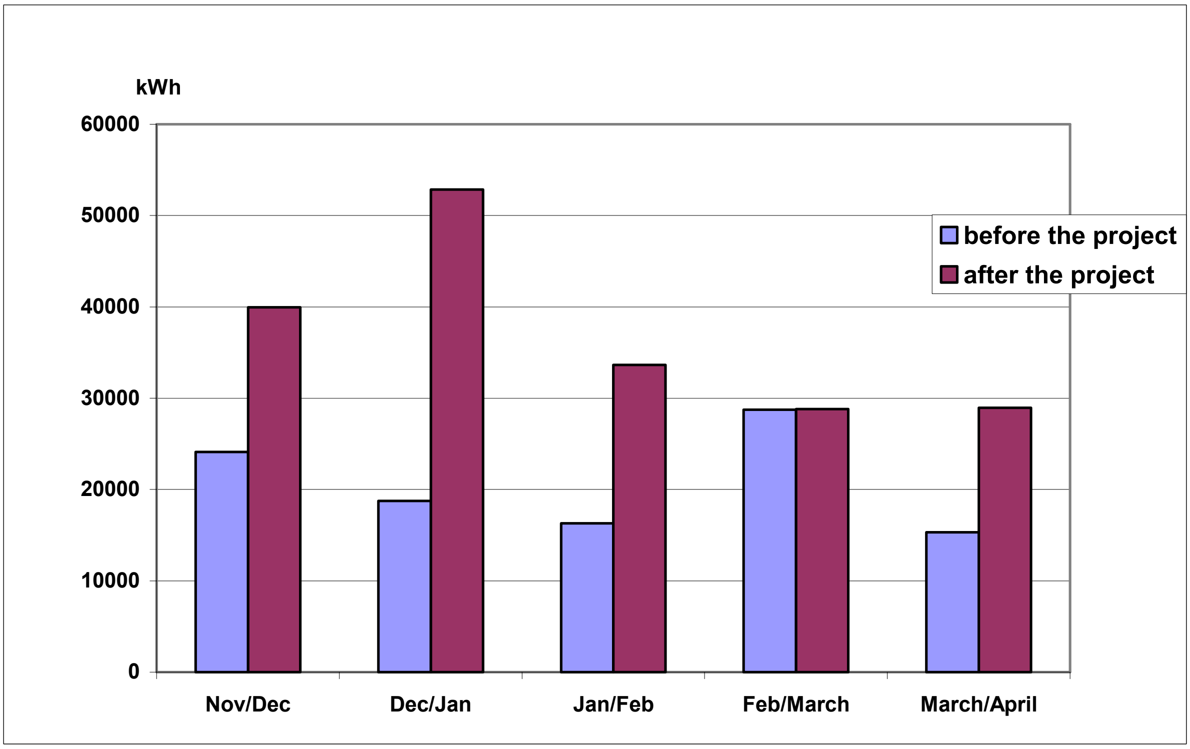


FIGURE 6: OSH PILOT AREA: TOTAL METERED CONSUMPTION IN APARTMENT BUILDINGS (2003 – 2004)



The initial data and information suggests that individual houses offer a greater potential for reduction of residential electricity losses. Thus, individual customer tamper-resistant electronic meters should first be installed at individual houses. Apartment buildings should be monitored using master meters to establish the urgency to replace individual meters of individual customers. Moreover, stronger efforts to track distribution electricity losses should be emphasized during the winter months when the incentive for theft is greater.

4.3. Distribution Network Level Electricity Losses

Below is an initial assessment of electricity technical losses and unmetered electricity consumption at the 0.4 kV distribution network level and at the 10 kV distribution network level, based on data and information collected at the two pilot areas.

4.3.1. Electricity Losses at the 0.4 kV Network Level

Balancing measurements at the 0.4 kV network level (input in to the 0.4 kV transformer substations against metered electricity consumption) is used to estimate the electricity losses at this network level during the monitoring period (November 2003 through April 2004). Figure 7 indicates that electricity losses were greater from November through January (45.4% and 32.9%) and less from February through April (23.0% to 19.4%) at the Bishkek pilot area. Figure 8 indicates that also at the Osh pilot area, the electricity losses were greater from mid-November through mid-January (41.4% and 33.8%) and less from mid-January through mid-April (22.3% to 10.6%). In both pilot areas the trend appears to be downward, as electricity losses for April were the lowest in Bishkek and Osh (19.4% and 10.6%, respectively).

The reasons for the observed downward trend in electricity losses during the performance monitoring period are not fully clear. One reason might be the higher electricity demand for heating during the coldest winter months, which increases the incentives for theft. Another reason might be attributed to greater attention paid by the distribution companies to tamper-resistant electronic metering data and information, resulting in more aggressive disconnection of illegal connections during the performance monitoring period.

International experience indicates that technical losses at the 0.4 kV network level range from 3% to 5%. Thus, excess electricity losses in the pilot areas are presumed to be unmetered electricity consumption, assuming that the infrastructure is comparable to international standards. It is not unreasonable to expect that these losses can be considerably lowered by sound management and constant monitoring of this segment of the distribution network.

In particular, the non-isolated 0.4 kV overhead lines that run close to individual houses are vulnerable to theft through unauthorized connections. TWEP discovered up to ten such connections during each pilot area visit during the performance monitoring period. In addition to the unmetered electricity consumption observed by individual houses, commercial enterprises (including kiosks), storage sheds, garages, and camps of transients appear to be connected illegally to the 0.4 kV network level, as well. When notified of these irregularities, the distribution companies did not take serious steps to correct the situation and pursue legal action against the individuals involved.

FIGURE 7: BISHKEK PILOT AREA: LOSSES IN 0.4 KV NETWORKS SERVING DISTRICTS WITH INDIVIDUAL HOUSES (2003 – 2004)

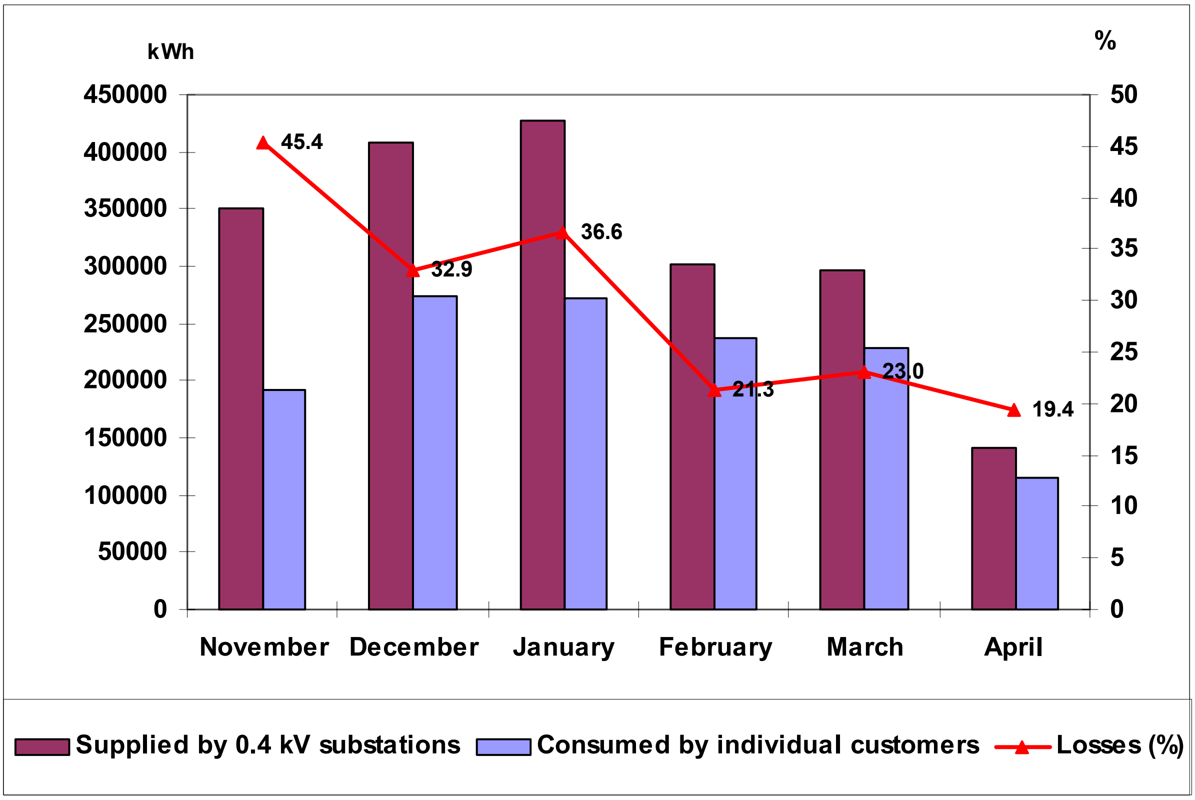
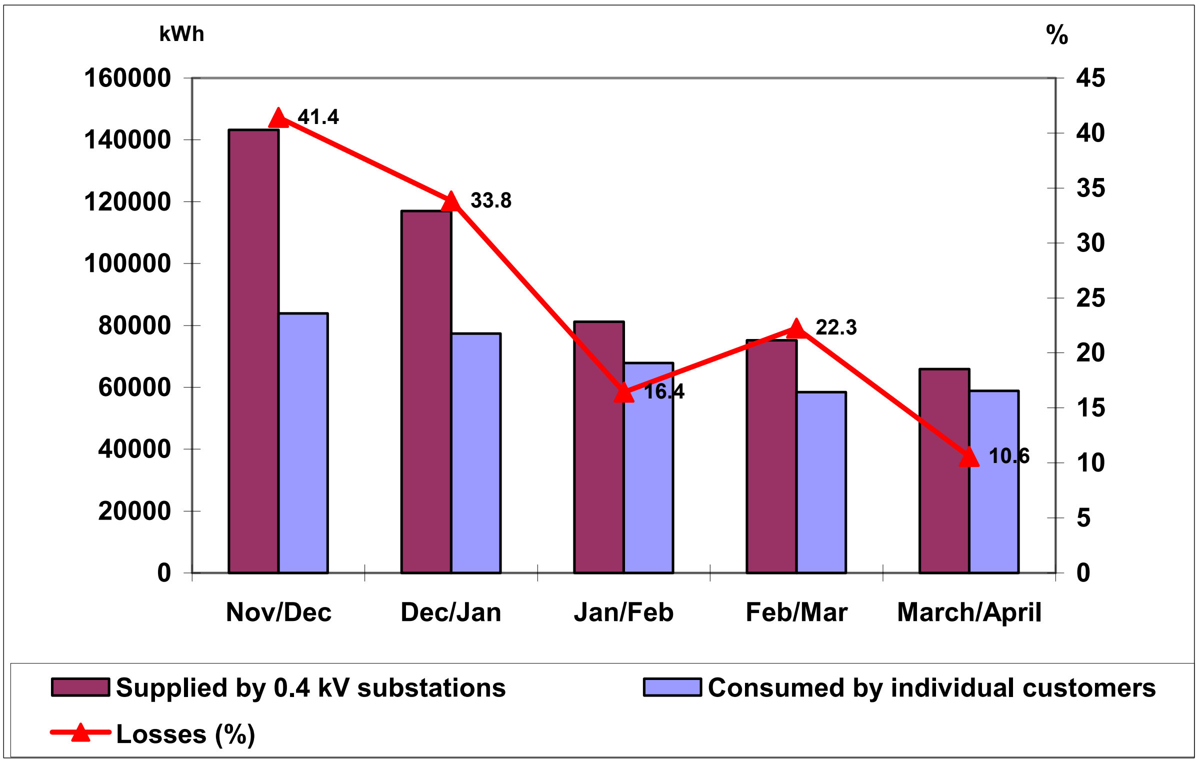


FIGURE 8: OSH PILOT AREA: LOSSES IN 0.4 KV NETWORKS SERVING DISTRICTS WITH INDIVIDUAL HOUSES (2003 – 2004)



4.3.2. Electricity Losses at the 10 kV Network Level

Balancing measurements at the non-extended 10 kV feeder level (input in to the feeder against output through 0.4 kV transformer substations) are used to estimate electricity losses at this distribution network level. International experience indicates that the normal level of expected technical losses in non-extended 10 kV feeders is within 2% to 3%.

Figure 9 indicates that electricity losses at the tamper-resistant electronic metering of the 10 kV network level in the Bishkek pilot area were 4.4% in December 2003, but increased up to threefold from January through April 2004 (11.4% to 14.2%). Figure 10 shows that international standards were met (0.8% to 2.0%) from mid-November 2003 through mid-February 2004 at the Osh pilot area. However, starting mid-February, electricity losses spiked upwards and reached levels of 10.24% in mid-March and 15.15% in mid-April.

FIGURE 9: BISHKEK PILOT AREA: BALANCE OF 10 KV FEEDER (2003 – 2004)

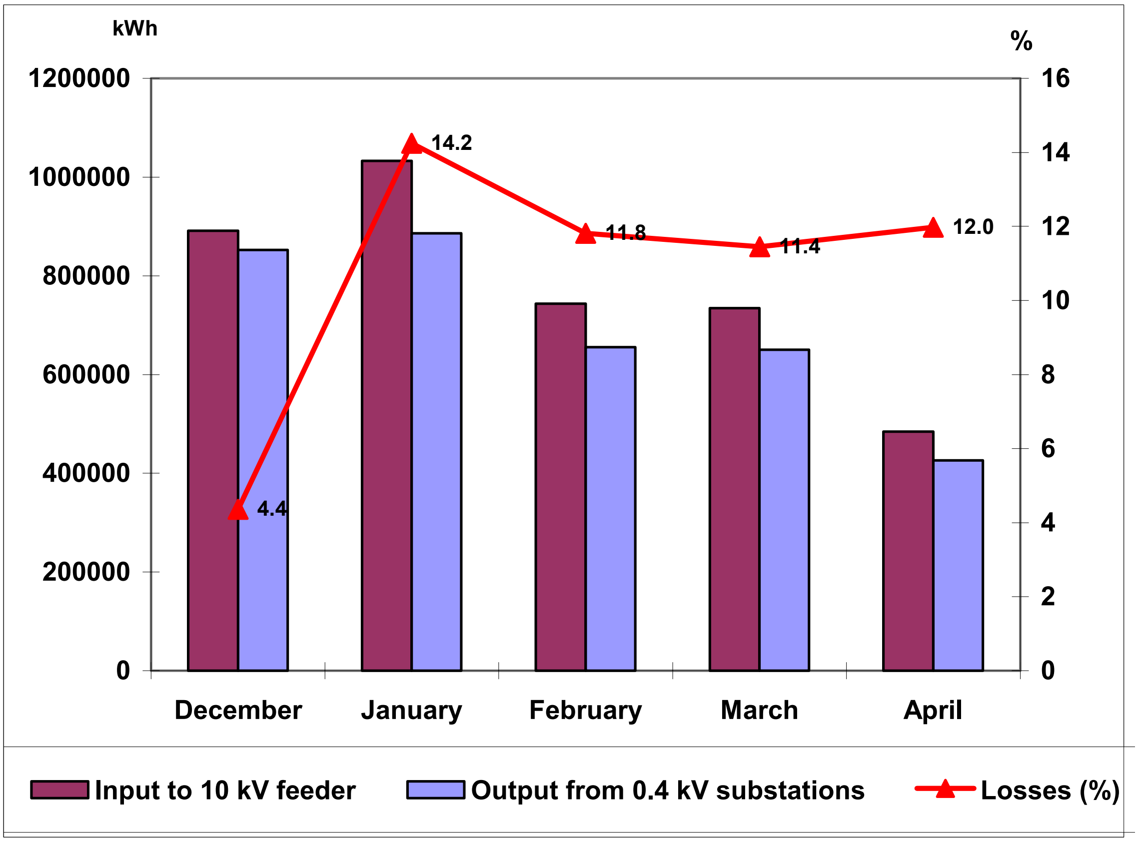
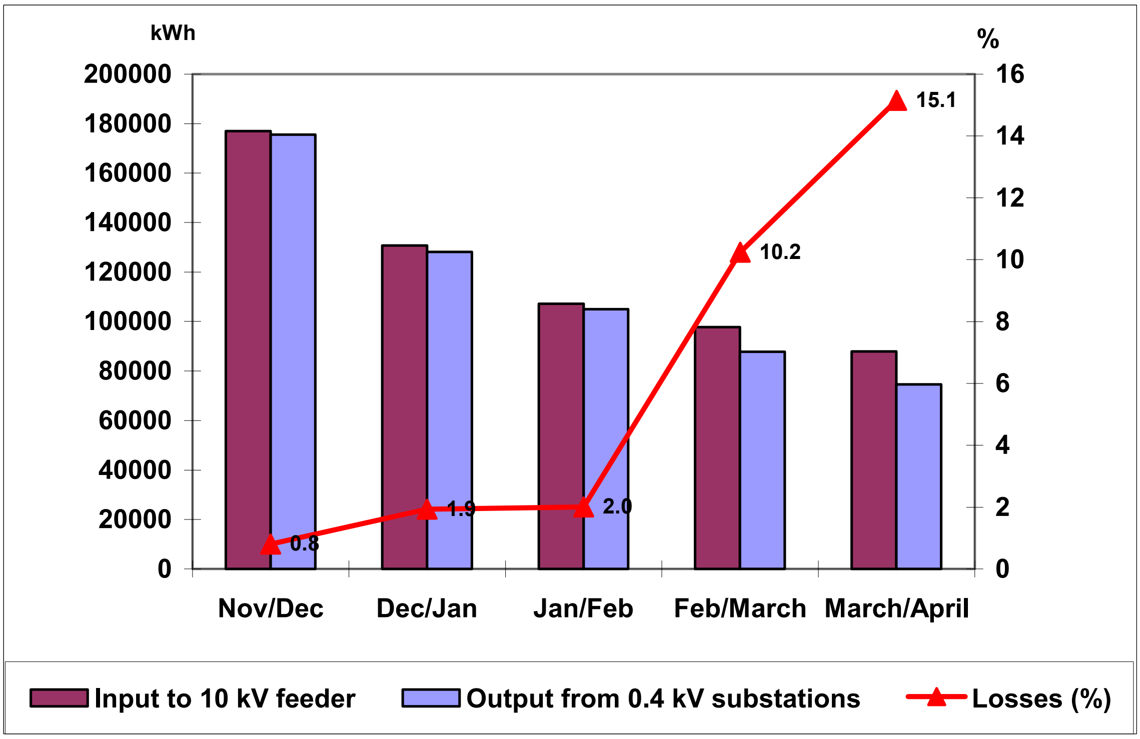


FIGURE 10: OSH PILOT AREA: BALANCE OF 10 KV FEEDER (2003 – 2004)



From this data, it could be presumed that the trending upwards of electricity losses can be explained by theft from the 0.4 kV transformer substations. It could be that most of this theft occurs at transformer substations that serve commercial enterprises outside the pilot areas. However, it's also possible that some of the 0.4 kV transformer substations connected to the non-extended 10 kV feeders have old defective meters, giving inaccurate readings. In any event, the data and information indicates that electricity losses dramatically increased in the last few months of the performance monitoring period.

The 10 kV network level needs further investigation, analysis, and collection of data and information to arrive at more credible conclusions and recommendations. As a first step, the two distribution companies must establish if the 0.4 kV transformer substations connected to the non-extended 10 kV feeders have defective meters through the proper balance of measurements. Once this is established, they can better identify illegal connections until this balance of measurements is reached.

4.3.3. Overall Electricity Loss Reduction Performance

With the limited data and information collected thus far, and taking into account many assumptions before the demonstration model was begun, it is difficult to make viable conclusions on the comparison of unmetered electricity consumption before and after the implementation of the demonstration model in the two pilot areas. As pointed out earlier in this report, many variables exist, which greater clarification and possible trends need to be further documented. Nevertheless, a comparison at this time could provide an order of magnitude of the overall electricity loss reduction performance of the two pilot areas. It must be understood that this comparison is limited, due to several factors, including:

- Deficiencies in metering infrastructure before project implementation; and

- The non-connected 10 kV feeders supply bulk electricity to large areas beyond the two pilot areas.

Taking this into account, Figure 11 illustrates two hypothetical scenarios that could be used to demonstrate how the reduction of unmetered electricity consumption can be estimated. The figure shows how assumptions and (sometimes, less than reliable) data and information existing before project implementation can be compared with current tamper-resistant electronic metering to establish the progress achieved. These hypothetical examples take into account, in a manner similar to the two pilot areas, an input of 100 kWh of electricity into the 10 kV segment of the network. It also shows how this electricity input would have been distributed based on the assumptions and data and information available during two different scenarios - Scenario M, corresponding to the performance monitoring phase covered in this report with the installation of tamper-resistant electronic meters and, Scenario B, before the demonstration model existed.

FIGURE 11: TWO HYPOTHETICAL SCENARIOS OF UNMETERED ELECTRICITY CONSUMPTION BEFORE PROJECT IMPLEMENTATION

ILLUSTRATION OF THE DETERMINATION OF UNMETERED CONSUMPTION BASED ON A HYPOTHETICAL CONSTANT DELIVERY OF 100 kWh AT THE 10 kV LEVEL BEFORE AND AFTER THE PROJECT

Line Number	Item	Column B Before Project	Comments to Column B	Column M Monitoring Phase	Comments to Column M
1	10kv input	100.00	meter reading	100.00	meter reading remains constant at level B1
2	10-0.4 kV Technical Loss	2.50	assumed constant at normal level	2.50	assumed constant at normal level
3	10-0.4 kV Unmetered Consumption	???	unknown	8.00	M1 less M2 less M8
4	0.4 kV input	???	unknown	89.50	meter reading
5	0.4 kV-customer Technical Loss	10.00	assumed constant at normal level	10.00	assumed constant at normal level
6	0.4 kV-customer unmetered consumption	???	unknown	20.00	M4 less M5 less M7
7	Customer Metered Consumption	23.15	meter reading	59.50	meter reading = 2.57 times B7
8	Customer Actual Consumption	87.50	assumed at constant level M8	87.50	M1 less M2 less M5
9	Total Loss	76.85	B5 less B7	40.50	M1 less M7
10	Technical Loss	12.50	B2 plus B5	12.50	M2 plus M5
11	Unmetered Consumption	64.35	B9 less B10	28.00	M9 less M10

Color Codes	
(red)	Old Meter Readings
(magenta)	New Meter Readings
(light green)	Assumed values based on reasonable information
(yellow)	Calculated values

Note the estimated level of more than 64% unmetered consumption before the project derived from new metering and the constant level of 10 kV input and technical loss

Note the persisting level of 28% unmetered consumption derived from new metering

In the case of Scenario M, shown in column M of the figure, average losses of 12.5% are observed, with the new tamper-resistant electronic metering capability at the input to the 0.4 kV transformer substation. This means that of the 100 kWh entering the 10 kV network only 89.5 kWh would be recorded at the 0.4 kV level (line 4 of column M in the table). Technical losses will account for 2.5 kWh (line 2) and, therefore, unmetered electricity consumption in the 10 kV to 0.4 kV segment is estimated at 8.00 kWh (line 3). The meter readings at the customer level show an average of 59 kWh (line 7). The technical losses in this segment can be safely estimated as 10 kWh (line 5). Therefore, unmetered electricity consumption in this segment is estimated at 20 kWh (line 6). Adding the unmetered electricity consumption in lines 3 and 6, the total unmetered electricity consumption of 28 kWh (line 11) is obtained. The actual consumption will then be the metered consumption (line 7) plus the unmetered consumption (line 11) or 87.5 kWh (line 8).

Scenario B, illustrated in column B of the figure represents the situation before project implementation. Based on the observations that the input to the 10 kV segment remained unchanged by the demonstration model, the same 100 kWh input can be assumed (line 1 of column B). There was no metering at the 0.4 kV level before project implementation, so all that is known is the customer metering, which was 23.15 kWh (line 7). However, it can be assumed that the technical losses (lines 2 and 5) were the same as those in Scenario M for the same power input. Since there were no major changes in temperature, it can also be assumed that customer habits remained the same. Therefore, following these assumptions, total consumption of electricity was the same as that for scenario M (line 8). Acceptance of all these assumptions provides the difference between metered consumption (line 7) and total consumption (line 8), with an estimate of 64.35 kWh in unmetered electricity consumption before project implementation (line 11).

Thus, while it is impossible to say how those electricity losses were distributed before (lines 3 and 6), it is possible to say that the demonstration model in the two pilot areas could very well have reduced unmetered electricity consumption by a factor of two. If this is viable, it results in additional metered electricity consumption of 36.35 kWh for every 100 kWh injected into the 10 kV segment of the network at the two pilot areas.

Since data and information indicates that an average of 479,014 kWh per month flows into the 10 kV segments in these two pilot areas, and the current average tariff is $0.0132 US per kWh, it can be estimated that up to $2,298 US per month is recoverable through 100% billing and collection of payments procedures. Therefore, even at the current level of electricity losses, which are still unacceptable by international standards, cost recovery of these two pilot areas could be financially and economically justified. Since the total cost of the demonstration model in the two pilot areas is $120,000 US, it can be reasonable to expect, even at this initial monitoring stage, that the cost of the loss reduction efforts can be recovered within approximately 48 months. This average payback period is representative for investments in metering for houses and apartments in both pilot areas. Based on initial data, it appears that investments in metering for houses are about three times more cost effective than investments in metering for apartments. In fact, under a more extensive project of large-scale metering replacement, and more aggressive enforcement and compliance, it would be reasonable to expect shorter periods of cost recovery.

In conclusion, the data and information at this preliminary level of performance monitoring suggests that significant improvement can already be claimed by the demonstration model of the two pilot areas, including:

- Due to upgrades in the distribution pilot areas, unmetered electricity consumption has been reduced, perhaps significantly in the reduction of technical losses and theft; and
- Investments in better metering can be economically and financially recovered within an acceptable timeframe.

4.4. Regulatory Authority of the State Energy Agency

The SEA was created in 1996 with the adoption of the Law “On Energy”. However, since its creation the SEA has floundered in its capabilities and authorities to regulate the electric power industry. Article 9 of the law clearly authorizes the SEA to:

- Enforce standards and normative documents on service delivery to the consumers of energy resources;
- Coordinate standards in the energy sector; and
- Adopt, issue, and monitor the proper implementation of resolutions, rules, regulations, guidelines, instructions, and other acts of a normative nature necessary to carry out its activities.

Unfortunately, the SEA has not been given the financial support nor the “political will” to properly regulate the electric power industry. Strengthening Government support of SEA authority and enforcement powers could result in better compliance of distribution companies, including lowering technical and non-technical electricity losses toward international standards. The inability of the SEA to create incentives and enforce conditions to reduce technical and non-technical electricity losses is merely an example of the multiple problems that exist in the Kyrgyz electric power sector.

4.5. Management of Distribution Companies

The Law “On Electricity” was adopted in 1997 and applies to all legal entities regardless of the form of ownership and individuals that generate, transmit, distribute, sell, or consume electricity and thermal power. The objectives of the law are aimed at assuring reliable, safe, and uninterrupted supply of electricity and thermal energy, and at improving the quality of service to all consumers, creating a competitive environment and energy market, encouraging development of the private sector, and attracting investments. Throughout the law there are several articles that address the technical and non-technical electricity loss problems that have been cited in this report (i.e., Articles 4, 14, 15, 16, 17, 23, 24, etc.). It is clear from the data and information gathered for this report that the electricity law is not being fully implemented, and less than full compliance by the electric power companies is evident.

4.5.1. Customer Metering, Billing and Collection System

Currently, the distribution companies use a customer metering, billing, and collections of payments system that does not allow for balancing of power flows in the various segments of the electricity networks. Data for residential and non-residential customers are stored in different non-related databases, with no balancing capabilities against master meters at the various levels in the network. Thus, power flows within the network cannot be tracked by the system to identify electricity losses, even if the all required metering infrastructure would be in place. Without an integrated customer metering, billing, and collections of payment system that reflects the power distribution “tree” and provides checks and balances, there is virtually no control of losses in the electricity distribution sector.

Recently, it has been confirmed that the electricity loss reduction projects will be replicated in much larger areas with funding from the World Bank, the Kreditanstalt fur Wiederaufbau (KfW) Germany, and the Switzerland State Secretariat for Economic Affairs (SECO). One of the components of the assistance provided by SECO would be the installation of a proper customer metering, billing and collections of payments system at all four distribution companies. This system would allow for automatic checks and balances of load measurements (master meters and individual customer meters), and the registration of all customers.

4.5.2. Internal Management Procedures

There are many opportunities to improve the internal control mechanisms and procedures of the distribution companies. During the implementation of the pilot areas several managerial and operational deficiencies have been identified. A few examples are given below.

Events such as replacement of damaged meters, connection of new customers, and other changes in the status of customers are not properly documented and registered in the records of the distribution companies. Where there are actual procedures specified, the procedures are often not followed. For example, Severelectro and Oshelectro do not keep an accurate account of the number of customers in the pilot areas. This situation makes it difficult to balance power delivered to a 0.4 kV transformer substation and the metered consumption by the customers connected to that substation.

Although procedures to connect new customers exist, there are no proper controls to ensure that these customers are actually added to the records of the distribution companies. During the implementation of the demonstration model in the two pilot areas, many unregistered customers have been identified, whom the responsible inspector/meter reader for these pilot areas had connected to the grid without following procedures. A major cleanup of the network and the registration of all connected customers did not provide a solution. Two months after the cleanup, several old and new, mostly commercial unregistered customers (including kiosks), were (again) illegally connected to the distribution network.

Inspectors and meter readers in charge of meter reading and collection seem more or less permanently assigned to a specific service territory and are not rotated, as recommended. This situation makes collusion between customers and meter readers and inspectors much more likely. The issue of inspectors with almost no control and accountability, coupled with the absence of the balancing mechanisms within the networks, prevents the full realization of benefits from the new metering infrastructure in the pilot areas. Specific management changes are required to solve the problem of theft (and inaccurate billing and incomplete collection).

4.5.3. Promising Managerial Actions

The distribution companies can easily mitigate the above examples of managerial and operational deficiencies, provided there is a genuine intention to increase revenues.

Load balances must be part of the routine of metering, billing and collection of payments. All meters must be crosschecked and their differences reported. Differences that exceed the norm for the technical losses in that particular circuit must be brought to the attention of the manager of commercial operations.

Meter reading operations must be carefully monitored at areas where high electricity loss rates are identified. This can be easily done through random sampling of monthly billings by independent inspectors. When a reported reading is found to be incorrect, the meter-reader must be placed under observation and their inspectors must review all the meters read by that particular meter-reader.

Meter readers must be trained to observe for signs of illegal connections. If electricity losses persist despite correct meter reading, then the inspectors must set up specific load flow monitoring routines to identify the dwellings where illegal connections may exist. Usually, the culprit is identified because electricity losses stop during the period that a dwelling is under close observation.

The prosecution of theft is a complex issue that may not be possible or cost-effective in every case. However, distribution companies should carefully select theft cases for prosecution, and prosecutors should work with the justice system to establish exactly the type of evidence required. Proper prosecution of electricity theft could set strong examples and would protect paying customers. These results should then be advertised in the neighboring area in order to discourage other fraudulent consumers.

These kind of managerial actions would be best carried out as part of a serious and sustained effort to control all forms of technical and non-technical losses, including theft, inaccurate billing, and incomplete collection. This would require the set up of a small but highly motivated task force that in this context could be known as the Electricity Loss Control Unit (ELCU). International experience shows that this can be successfully done by hiring outside contractors, which are compensated on the basis of, recaptured revenue. Due to the fact that this modality could have other adverse consequences, it is recommended that the ELCU will be an internal unit inserted in the distribution company, appointed by and directly answerable to the SEA.

The ELCU must be empowered to look into every aspect of the operational chain between metering, billing and collection of payments. It must have periodic meetings with the SEA to report irregularities uncovered and recommend specific actions. The ELCU will conduct three major types of activities: instruction, monitoring and enforcement as follows.

Instruction involves meeting with the manager for commercial operations to discuss how meter readers are assigned with a view to organize rotations to prevent collusion between meter readers and customers. It also involves holding meetings with groups of meter readers to notify them that they are being monitored and request that they immediately report any irregularity known to them in their service areas. Meter readers should be given a grace period to report irregularities without fear of punishment. However, they must be made aware that beyond the grace period, any failure to report irregularities will entail serious administrative action, and could bring legal action for damages against the distribution company.

Monitoring involves requesting the manager of commercial operations for monthly reports of load balances and non-technical loss computation. Any failure to receive such data promptly must be dealt with swiftly by requesting top management to put in place the procedures for the determination of non-technical losses in areas where metering is adequate. The SEA will take strong action to procure the means for distribution companies to carry out this most important procedure. The ECLU will use the data to correlate losses with individual meter-readers, and to place them under observation and start collecting evidence for prosecution of meter-readers and fraudulent customers.

Enforcement must emanate directly from the SEA through the recommendations of the ELCU assigned to a specific distribution company. ELCU recommendations may include:

- Administrative actions against company personnel involved in theft;
- Rewards to company personnel credited with reporting theft; and
- Legal prosecution to seek damages from corrupt inspectors and meter readers and fraudulent consumers in electricity theft.

5. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be drawn from the initial data and information of performance monitoring of the electricity loss reduction pilot areas in Bishkek and Osh:

- **Changes in Metered Consumption:** Major increases in metered electricity consumption were recorded in both pilot areas in comparison with the baseline period before demonstration model implementation. Tamper-resistant electronic metered consumption of individual houses has increased by 257% in Bishkek and 179% in Osh. The increase in metered electricity consumption in the apartment buildings in both areas was less and ranged between 10% in Bishkek to 80% in Osh. The initial data and information collected as a result of these two pilot areas indicate that individual houses offer a greater potential for reduction of residential electricity losses. Apartment buildings should be monitored using master meters to establish the urgency to replace individual meters of individual customers.
- **Electricity Losses at the 0.4 kV Network Level:** Despite the major increase in metered electricity consumption, there remains a high level of electricity losses at the 0.4 kV network levels. Electricity losses were recorded at higher levels in both Bishkek and Osh during November through January (45.4% to 32.9%) and at lower levels from February through April (23.0% to 10.6%). During this monitoring period, it was observed that there was a general downward trend of electricity losses (greater than 100% in Bishkek and nearly 200% in Osh). These abnormally high electricity losses can only for a minor part be explained by technical losses. International experience indicates that the normal level of expected technical losses at the 0.4 kV network level range from 3% to 5%. Thus, excess electricity losses in the pilot areas are presumed to be unmetered electricity consumption, assuming that the infrastructure is comparable to international standards. Further data and information need to be collected to justify any conclusions. However, initial impressions are that incentives for unmetered electricity consumption are greater during colder winter months, since electricity is the primary form of heat for individual houses in the two pilot areas. It could also be that the two distribution companies are enforcing more aggressive disconnections of illegal connections during the later months of the performance monitoring period, based on better metering systems.
- **Electricity Losses at the 10 kV Network Level:** Despite the major increase in metered electricity consumption, there remains a high level of electricity losses at the 10 kV network levels after the installation of the tamper-resistant electronic metering infrastructure. The electricity losses at the tamper-resistant electronic metering of the 10 kV network level in the Bishkek pilot area were 4.4% in December 2003, but increased up to threefold from January through April 2004 (11.4% to 14.2%). After low levels of electricity losses during the first three monitoring months in the Osh pilot area (0.8% to 2.0% from mid-November 2003 until mid-February 2004), they spiked upwards and reached levels of 10.24% in mid-March and 15.15% in mid-April. International experience indicates that the normal level of expected technical losses in non-extended 10kV feeders is within 2% to 3%. Thus, the excess electricity losses consist of unmetered electricity consumption from the 0.4 kV transformer substations connected to the 10kV feeders inside and outside of the pilot areas. However, it’s also possible that some of the 0.4 kV transformer substations outside the pilot area have old defective meters, giving inaccurate readings. In any event, the data and information indicate that

electricity losses dramatically increased in the last few months of the performance monitoring period.

- **Overall Distribution Electricity Losses:** As sufficient metering infrastructure is now in place in the two pilot areas, the high levels of unmetered consumption at the 0.4 kV and 10 kV network levels can only be explained by lack of management or enforcement capability at both distribution companies. It is not unreasonable to expect that these electricity losses can be considerably lowered by sound management and constant monitoring of this segment of the distribution network.
- **Legal and Regulatory Enforcement:** It is apparent that the SEA does not have the support (i.e., financing and political will) from the Government that is necessary to properly conduct its responsibilities and authorities in the regulation of the electric power sector. The problems of high technical and non-technical electricity losses are only an indicator of many other non-compliance issues by these natural monopolies.
- **Management Practices:** The apparent high levels of unmetered electricity consumption after the installation of tamper-resistant electronic metering, and the collection of reliable data and information, highlight the need for a serious review of management practices by the distribution companies. The continued persistence of illegal connections observed well after these were clearly identified, indicates a disturbing lack of willingness or enforcement capability.
- **Management System:** A proper system of checks and balances for both load measurements (master meter and individual meters) and the registration of all customers is essential to extract the benefit of any investment in new metering infrastructure**.**
- **Overall Performance of the Demonstration Model:** Despite the persistent high level of electricity losses, significant improvement can be claimed by the implementation of the demonstration model in the two pilot areas, including:
    - Due to upgrades in the distribution pilot areas, unmetered electricity consumption has been reduced, perhaps significantly in the reduction of technical losses and theft; and
    - Investments in better metering can be economically and financially recovered within an acceptable timeframe.

It is a well-known fact by the donors and international financial institutions that the Laws "On Energy" and "On Electricity" have never been properly implemented since their adoption. It is recognized that the electric power natural monopoly companies are not being properly regulated by the SEA, due to the general lack of agency financing and "political will" by the Government. It is recommended that the Government strongly supports the SEA, so that it can properly conduct its duties and responsibilities, and correct the technical and non-technical electricity losses problem, which includes adoption and enforcement of:

- Strong penalties for theft of electricity;
- Customer metering, billing, and collection of payments system;
- Distinct and stringent disconnection and reconnection policies;
- A schedule for the gradual increase of tariff rates to eventually ensure the recovery of costs, and provide confidence for investment in system upgrades;

- A safety net program that subsidizes electricity payments for vulnerable low income customers; and
- Regulatory oversight of management, administration, and operational behavior of electric power natural monopolies (generation, transmission, and distribution).

Additionally, the following immediate measures to reduce distribution electricity losses are recommended:

- Install and implement a proper system of checks and balances for both load measurements (master meter and individual meters), and the registration of all customers;
- Give priority to tamper-resistant electronic metering improvements at individual houses. Apartment buildings should be monitored using master meters to establish the priority for replacement of the individual meters of each apartment;
- Reduce electricity losses at the 10 kV level by identifying first if all 0.4 kV transformer substations connected to the 10 kV feeder have any defective meters through proper balancing of power measurements, and then identify and remove illegal connections until that feeder's balance (input = output - technical losses) is reached;
- Make inspectors and their meter-readers directly responsible for explaining the difference between the master meter readings at each 0.4 kV transformer substation and the total metered consumption by customers in the area served by each transformer substation;
- Rotate meter-readers among service areas in order to prevent collusion between meter-readers and customers;
- Timely remove illegal connections to the 0.4 kV transformer substations and to the 0.4 kV network, including portable kiosks, storage sheds, garages, and camps of transients;
- Take legal action against persistent illegal connections in the pilot areas to illustrate that theft will not be tolerated by the distribution companies; and
- Apply disconnection procedures of non-paying customers, as described in the contract between the distribution company and the customer, and approved by the SEA.

In addition, it is recommended that the SEA and distribution companies follow up with a serious and sustained effort to control all forms of non-technical losses, including theft, inaccurate billing and incomplete collection through:

- The establishment of a small, but highly motivated ELCU, inserted in the distribution company by the SEA, and directly answerable to this agency.
- Providing authority to the ELCU to look into every aspect of the operational chain between metering and collection. It would conduct three major types of activities: instruction, monitoring and enforcement.
- Drawing staff of the ELCU from different distribution companies to prevent the persistence of corruption. They would receive special incentive compensation based on results achieved.

The above conclusions and recommendations will be discussed with Severelectro, Oshelectro, the SEA, key Government officials, USAID and other donors, and international financial institutions that support reforms in the Kyrgyz energy sector, and plan to replicate the demonstration model in a larger scale.

To further reduce losses in both pilot areas, TWEP is considering providing further technical assistance and training on this issue to the management of Severelectro and Oshelectro. These companies and the SEA should also consider the implementation of country-wide public outreach activities targeted at the issues of tariff setting and cost recovery, metering, billing, collection of payments, and disconnection and reconnection policies.

ANNEX 1. TOTAL METERED ELECTRICITY CONSUMPTION OF INDIVIDUAL HOUSES

Bishkek Pilot Area: Total Metered Electricity Consumption of Individual Houses (kWh)

			2002/2003						2003/2004					
			Nov	Dec	Jan	Feb	Mar	Apr	Nov	Dec	Jan	Feb	Mar	Apr
1	Substation 1441		37,324	41,225	46,087	39,405	35,401	32,788	89,717	124,845	118,780	100,710	94,387	43,141
2	Substation 1408		2,835	2,315	2,675	2,715	3,523	3,646	10,303	13,012	15,732	23,095	20,789	11,522
3	Substation 1986		23,657	30,682	31,087	24,658	24,925	18,790	48,219	82,131	78,229	69,235	62,308	36,597
4	Substation 1973		7,214	7,724	6,755	6,347	5,158	4,576	29,025	36,381	39,754	28,612	30,928	13,970
5	Substation 2021		5,442	6,065	7,036	4,739	4,950	4,612	14,004	17,264	18,792	15,526	20,496	9,141
6	**TOTAL**		**76,472**	**88,011**	**93,640**	**77,864**	**73,957**	**64,412**	**191,268**	**273,633**	**271,287**	**237,178**	**228,908**	**114,371**
	Increase (%)									**310.9**	**289.7**	**304.6**	**309.5**	**177.6**

Bishkek Pilot Area: Total Metered Electricity Consumption per Customer (kWh)

		# Customers	2002/2003						# Customers	2003/2004					
			Nov	Dec	Jan	Feb	Mar	Apr		Nov	Dec	Jan	Feb	Mar	Apr
1	Substation 1441	**124**	301	332	372	318	285	264	**130**	690	960	914	775	726	332
2	Substation 1408	**9**	315	257	297	302	391	405	**10**	1,030	1,301	1573	2310	2079	1,152
3	Substation 1986	**58**	408	529	536	2,740	2,769	2,088	**69**	699	1,190	1,134	1,003	903	530
4	Substation 1973	**14**	515	552	483	705	573	508	**15**	1,935	2,425	2,650	1,907	2,062	931
5	Substation 2021	**17**	320	357	414	527	550	512	**23**	609	751	817	675	891	397
6	**TOTAL**	**222**	**344**	**396**	**422**	**351**	**333**	**290**	**247**	**774**	**1108**	**1098**	**960**	**927**	**463**
	Increase (%)										**279.4**	**260.4**	**273.8**	**278.2**	**159.6**

Osh Pilot Area: Total Metered Electricity Consumption of Individual Houses (kWh)

			2002/2003					2003/2004				
			Nov/Dec	Dec/Jan	Jan/Feb	Feb/Mar	Mar/Apr	Nov/Dec	Dec/Jan	Jan/Feb	Feb/Mar	Mar/Apr
1	**Substation 479**		14,510	17,139	15,267	13,365	15,242	34,728	31,953	31,686	24,750	23,477
2	**Substation 857**		6,802	8,806	6,433	6,295	8,422	20,433	17,896	13,424	13,178	15,906
3	**Substation 1045**		640	1,674	1,205	1,010	1,411	5,290	5,336	5,089	3,337	3,146
4	**Substation 1082**		1,611	4,981	8,672	7,573	8,421	7,855	8,215	6,136	6,803	6,576
5	**Substation 1216**		686	4,995	1,898	1,874	1,508	4,221	4,359	3,850	4,381	4,817
6	**Substation 546**		5,181	4,670	6,950	9,707	10,019	11,362	9,644	7,679	6,011	4,977
7	**TOTAL**		**29,430**	**42,265**	**40,425**	**39,824**	**45,023**	**83,889**	**77,403**	**67,864**	**58,460**	**58,899**
	Increase (%)								**183.1**	**167.9**	**146.8**	**130.8**

Osh Pilot Area: Total Metered Electricity Consumption per Customer (kWh)

		# Customers	2002/2003					# Customers	2003/2004				
			Nov/Dec	Dec/Jan	Jan/Feb	Feb/Mar	Mar/Apr		Nov/Dec	Dec/Jan	Jan/Feb	Feb/Mar	Mar/Apr
1	**Substation 479**	**50**	290	343	305	267	305	**50**	695	639	634	495	470
2	**Substation 857**	**46**	148	191	140	137	183	**46**	444	389	292	286	346
3	**Substation 1045**	**8**	80	209	151	126	176	**8**	661	667	636	417	393
4	**Substation 1082**	**18**	90	277	482	421	468	**18**	436	456	341	378	365
5	**Substation 1216**	**13**	53	384	146	144	116	**13**	325	335	296	337	371
6	**Substation 546**	**14**	370	334	496	693	716	**14**	812	689	549	429	356
7	**TOTAL**	**149**	**198**	**284**	**271**	**267**	**302**	**149**	**563**	**519**	**455**	**392**	**395**
	Increase (%)									**183.1**	**167.9**	**146.8**	**130.8**

ANNEX 2: ELECTRICITY LOSSES AT 0.4 KV NETWORK LEVEL

Bishkek Pilot Area: Electricity Losses at the 0.4 kV Network Level (kWh)

2003/2004		Substation 1441	Substation 1408	Substation 1986	Substation 1973	Substation 2021
November	Input	148,002	24,910	96,264	62,460	18,720
	Consumption	89,717	10,303	48,219	29,025	14,004
	Losses	58,285	14,607	48,045	33,435	4,716
	Losses (%)	39.4	58.6	49.9	53.5	25.2
December	Input	162,560	39,040	134,160	44,460	27,800
	Consumption	124,845	13,012	82,131	36,381	17,264
	Losses	37,715	26,028	52,029	8,079	10,536
	Losses (%)	23.2	66.7	38.8	18.2	37.9
January	Input	167,880	45,840	124,800	57,840	31,547
	Consumption	118,780	15,732	78,229	39,754	18,792
	Losses	49,100	30,108	46,571	18,086	12,755
	Losses (%)	29.2	65.7	37.3	31.3	40.4
February	Input	133,869	32,440	82,560	29,880	22,640
	Consumption	100,710	23,095	69,235	28,612	15,526
	Losses	33,159	9,345	13,325	1,268	7,114
	Losses (%)	24.7	28.8	16.1	4.2	31.4
March	Input	121,360	26,000	87,840	36,660	25,360
	Consumption	94,387	20,789	62,308	30,928	20,496
	Losses	26,973	5,211	25,532	5,732	4,864
	Losses (%)	22.2	20.0	29.1	15.6	19.2
April	Input	53,360	13,800	44,760	18,540	11,360
	Consumption	43,141	11,522	36,597	13,970	9,141
	Losses	10,219	2,278	8,163	4,570	2,219
	Losses (%)	19.2	16.5	18.2	24.6	19.5

Osh Pilot Area: Electricity Losses at the 0.4 kV Network Level (kWh)

2003/2004		Substation 479	Substation 857	Substation 1045	Substation 1082	Substation 1216	Substation 546
November/ December	Input	47,340	47,760	5,559	15,120	9,280	18,150
	Consumption	34,728	20,433	5,290	7,855	4,221	11,362
	Losses	12,612	27,327	269	7,265	5,059	6,788
	Losses (%)	26.6	57.2	4.8	48.0	54.5	37.4
December/ January	Input	45,060	34,680	6,025	10,440	6,440	14,340
	Consumption	31,953	17,896	5,336	8,215	4,359	9,644
	Losses	13,107	16,784	689	2,225	2,081	4,696
	Losses (%)	29.1	48.4	11.4	21.3	32.3	32.7
January/ February	Input	33,480	21,720	5,489	6,515	5,265	8,730
	Consumption	31,686	13,424	5,089	6,136	3,850	7,679
	Losses	1,794	8,296	400	379	1,415	1,051
	Losses (%)	5.4	38.2	7.3	5.8	26.9	12.0
February/ March	Input	30,660	19,200	4,855	7,440	6,200	6,840
	Consumption	24,750	13,178	3,337	6,803	4,381	6,011
	Losses	5,910	6,022	1,518	637	1,819	829
	Losses (%)	19.3	31.4	31.3	8.6	29.3	12.1
March/April	Input	25,920	17,100	3,738	6,840	6,140	6,140
	Consumption	23,477	15,906	3,146	6,576	4,817	4,977
	Losses	2,443	1,194	592	264	1,323	1,163
	Losses (%)	9.4	7.0	15.8	3.9	21.5	18.9

ANNEX 3. TOTAL METERED ELECTRICITY CONSUMPTION AND LOSSES IN APARTMENT BUILDINGS (2003 – 2004)

Bishkek Pilot Area: Electricity Consumption and Losses in Apartment Building (kWh))

	November	December	January	February	March	April
Before the project	15,875	19,710	16,023	15,319	14,500	14,480
After the project	18,486	19,816	18,592	16,781	16,864	14,483
Master Meter	18,502	19,800	18,990	18,150	17,910	14,850
Losses	16	-16	398	1,369	1,046	367
Losses (%)	0.09	-0.08	2.10	7.54	5.84	2.47

Osh Pilot Area: Electricity Consumption and Losses in Apartment Building (kWh)

		November/ December	December/ January	January/ February	February/ March	March/ April
Before the project		24,129	18,757	16,302	28,754	15,312
After the project		39,947	52,841	33,660	28,809	28,942
Master Meter		84,060	59,460	34,200	31,380	29,580
Losses		44,113	6,619	540	2,571	638
Losses (%)		52.48	11.13	1.58	8.19	2.16